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ABSTRACT

Eighty college students with no computer programing experience were the subjects of a study to determine the effects of the use of advanced organizers and subject control of instruction on performance. Students either received a logical or a scrambled sequence of instructional frames on computer programing, were either allowed to alter the order of the frames or were not, and either received pretraining with a concrete model of a computer or did not. On a test the students who had pretraining with the model and controlled the order of the instructional frames performed better on far transfer items: those with no model pretraning and experimenter controlled instructional frames performed better on straightforward problems. There were no reliable effects due to sequencing of frames. (Author/JY)

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Differences in Breadth of Transfer due to Advance Organizers and Subject Control of Frame Sequencing

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ABSTRACT

Eighty non-programmers either received pretraining with a concrete model of the computer or not (Model vs. No Model), received either a Logical or Scrambled sequence of text frames for computer programming, and were either allowed to alter the order or not (S vs. E control). On a test, Model pretraining and S-control resulted in better performance on far transfer items, while No Model pretraining and E-control resulted in superior performance on straightforward problems. There were no reliable effects due to sequencing of frames. Implications for instruction for technical information were discussed.

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Objectives and theory. Mayer and Greeno (1972) have suggested that meaningful learning depends on the following processes: (1) receiving the to-be-learned information, (2) having a meaningful learning set available to which new information may be assimilated, (3) actively processing or activating the meaningful learning set during learning. The present experiment investigated three factors influencing the acquisition of a technical computer programming language by non-programmers--pretraining with a concrete model of the computer expressed in familiar terms (which may influence the availability of a meaningful learning set), subject control over the order of presentation of instructional frames (which may influence the activation of a meaningful learning set), and logical vs. scrambled sequencing of text frames (which may influence the amount of information received).

According to Ausubel's (1968) concept of "advance organizers," pretraining with the model could help establish a meaningful learning set, and result in a qualitatively different kind of learning outcome as compared to non-model subjects who assimilated information to a less meaningful learning set. Differences in the transfer performance--the pattern of transfer--would be predicted between the Model and No Model subjects. Similarly, subject control could result in active cognitive involvement (e.g., as suggested by Rothkopf's (1970) concept of "mathemagenic activity"); hence such subjects would assimilate new information to a different type of set than Experimenter-control subjects, and develop qualitatively different learning outcomes. Again, differences in the pattern of transfer performance would be predicted. Finally, the sequencing of material may result in overall differences if the material is highly sequential and lengthy, but no difference in the pattern of transfer is predicted.

Data source. The subjects were 80 Indiana University students who participated in the experiment in order to fulfill a requirement for their introductory

psychology course. Subjects had no prior experience with computer programming and correctly solved at least 3 of 5 algebra substitution problems.

Method. A 2 x 2 x 2 factorial design was used with ten subjects per cell. The factors were whether or not a concrete model of the computer was presented prior to learning (Model vs. No Model organizer), the sequencing of the 26 frames of instruction (Logical vs. Scrambled order), and whether subjects could alter the given ordering of frames (S vs. E control).

The concrete model presented the computer in familiar terms and consisted of a 3 x 2 ft. board with the following attachments: a small chalkboard divided into 8 squares (described as a "memory scoreboard"), two envelopes labeled "in" and "out" with small data cards for input (described as a "ticket window"), a note pad and pencil for output (described as a "telephone pad"), and an index card with numbers 1, 2, 3, etc. down the margin and a pointer arrow for executive control (described as a "shopping list").

The 26-frame text consisted of 26 4 x 6 in. typed index cards with approximately 100 to 200 words per card. Each card was numbered and labeled on one side with the text on the other side. The text gave definitions and examples of seven basic computer programming statements (READ, WRITE, IF, GO TO, STOP, Arithmetic, Assignment) and appropriate grammar and format rules. No mention of the model was made in the text although Model subjects were asked to try to relate the model to the text during learning.

An 18-card deck of test questions consisted of two types of questions (Generation of a program given a problem and Interpretation of what problem a given program would solve) and three levels of difficulty (Single Statement, Short Non-looping Program, and Looping Program) yielding six kinds of questions. For example, a generation/non-looping problem is, "Given that a card with a number on it is input, write a program to print out that number unless it is

greater than 5." A generation/looping problem is, "Given a pile of data cards is input write a program to print out each number and stop when it gets to a card with 88 on it." An interpretation/looping problem is, "Given the program

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P1  READ(A1)
P2  IF(A1=88) GO TO P5
P3  WRITE(A1)
P4  GO TO P1
P5  STOP                ,"
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the subject must answer that a pile of cards is input and list of numbers output, and that the program solves the problem above.

Subjects were randomly assigned to treatments and run in groups of 2 to 4 per session. Subjects in the MOdel group received the model and a 150-word explanation prior to learning and were allowed to refer to the model during learning, while the No Model subjects proceeded directly to the instructional frames. For the instruction, subjects read each of 26 frames individually and at their own rates with only one reading allowed per card. Subjects in the Logical group were given the deck of 26 cards numbered in an order typical of a standard textbook presentation, while the deck of cards of Scrambled subjects was numbered and ordered in a random sequence. Subjects in the E-control group read the cards in the order given (either Uogical or Scrambled) while the S-control group was given a "Table of Contents" listing the cards (in either Logical or Scrambled order) and could ask for the cards, by number or name, in any order from the table. After reading the 26 cards, all subjects received the same 18-item test.

Results. An analysis of variance was performed on the results of the test with each item scored as either right or wrong. The proportion correct for each kind of test item is summarized in the table below. Since there

were no reliable overall or interactive effects due to sequencing of the 26 frames (i.e. logical vs. scrambled) the data in the table have been collapsed over that factor. Apparently, the present material was either short enough or redundant enough to be held in memory, or the material was not highly sequential in nature.

There was an overall superiority of subjects receiving pretraining with the model over subjects who did not ($p < .02$) and there was also a reliable pattern of interaction in which Model subjects excelled on problems involving far transfer such as looping or interpretation and No Model subjects excelled on problems similar to those in the text (Model x Type, $p < .01$; Model x Difficulty, $p < .10$; Model x Type x Difficulty, $p < .01$). These interactions confirm earlier findings using a similar model in diagram form (Mayer, 1975) and suggest that the model may have served to provide a meaningful learning set which allowed the subject to encode the text material more broadly and to relate it more easily to other familiar experiences.

There was no overall difference between subjects who controlled the order of presentation of frames and those who did not, but there was an interesting pattern of interaction between Control x Difficulty ($p < .01$) in which the S-control subjects excelled on far transfer problems such as looping while the E-control subjects excelled on more straightforward problems. Apparently, S-control results in deeper, more active encoding, which allowed subjects to relate the text to other familiar experiences. More research is required to determine whether subject control and a meaningful model have similar effects on the activation of a meaningful learning set.

Group	Generation			Interpretation		
	Statement	Non-Loop	Looping	Statement	Non-Loop	Looping
Model/S-Control	.60	.73	.38	.53	.55	.32
Model/E-Control	.70	.50	.30	.60	.48	.07
No Model/S-Control	.47	.62	.13	.22	.30	.07
No Model/E-Control	.62	.52	.13	.37	.28	.00

Supplemental study. In order to more carefully investigate the role of the meaningful model as an advance organizer, subjects were given the text frames in the logical order and under E-control but received the model either before (Group Before) or after (Group After) reading the frames. According to Ausubel's concept of "assimilation" to "meaningful learning set", broader learning is predicted only for the Before Group. Twenty subjects served in each group, and used the same basic procedure, materials and test as in the previous study.

The proportion correct on the posttest is summarized below. An analysis of variance revealed that the Before Group performed better overall than the After Group ($p < .01$); in addition, the Before Group performed especially better than the After Group on complex or "far transfer" problems (Model Before x Type, $p < .01$; Model Before x Type x Difficulty, $p < .05$).

Group	Generation			Interpretation		
	Statement	Non-Loop	Looping	Statement	Non-Loop	Looping
Model Before	.68	.51	.24	.55	.70	.22
Model After	.69	.50	.06	.29	.38	.10

Educational Implications. These results have direct implications for the design of instruction for technical information. The present findings extend earlier results (Mayer, 1975) that a meaningful model presented prior to instruction can serve as a meaningful learning set (Ausubel, 1968), allowing

broader encoding of information and wider transfer. Some models that are familiar (e.g., our concrete model of the computer) apparently allow subjects to encode new technical information in terms of their past experiences and thus achieve broader learning outcomes as compared to subjects who learn without benefit of a model. Subject control of the instructional material may have a similar effect by encouraging subjects to actively "think about" the new learning. More research is required to determine the characteristics of a "good" model, individual differences in its usefulness, and the limits of the usefulness of subject control.

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